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DYNAMIC EXPLICIT ANALYSIS AND ASSESSMENT OF A SHIPS STEERING GEAR

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Underwater Explosions

Our business: industrial engineering

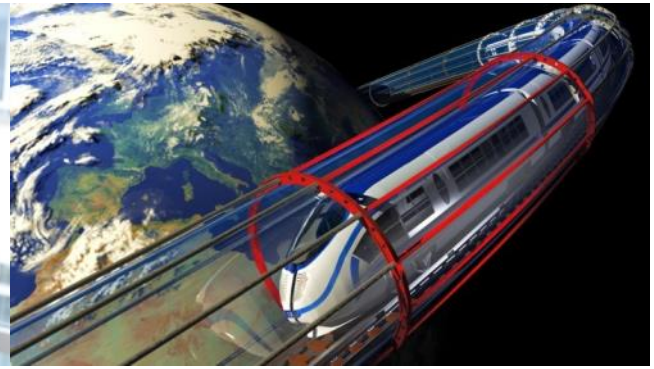
KEY FIGURES

Nearly €900m revenue

Main business sectors:

- Aerospace
- Transportation
- Energies

12,000 employees



Our mission

To enable our customers to embrace the Growth to be

- Supporting their product development and investment management throughout the life cycle
- Delivering Energy & Infrastructure Engineering and Global Product Solutions
- Worldwide

Our added value

- A culture of safety
- Management of complex projects
- The depth of our skills and vertical expertise

50 years of growth

EARLY NUCLEAR YEARS

1966 - 1995

1996 - 2003

TOWARDS DIVERSIFICATION

2003 - 2010

INTERNATIONAL DEVELOPMENT

Since 2011

A NEW PATH TO GROWTH

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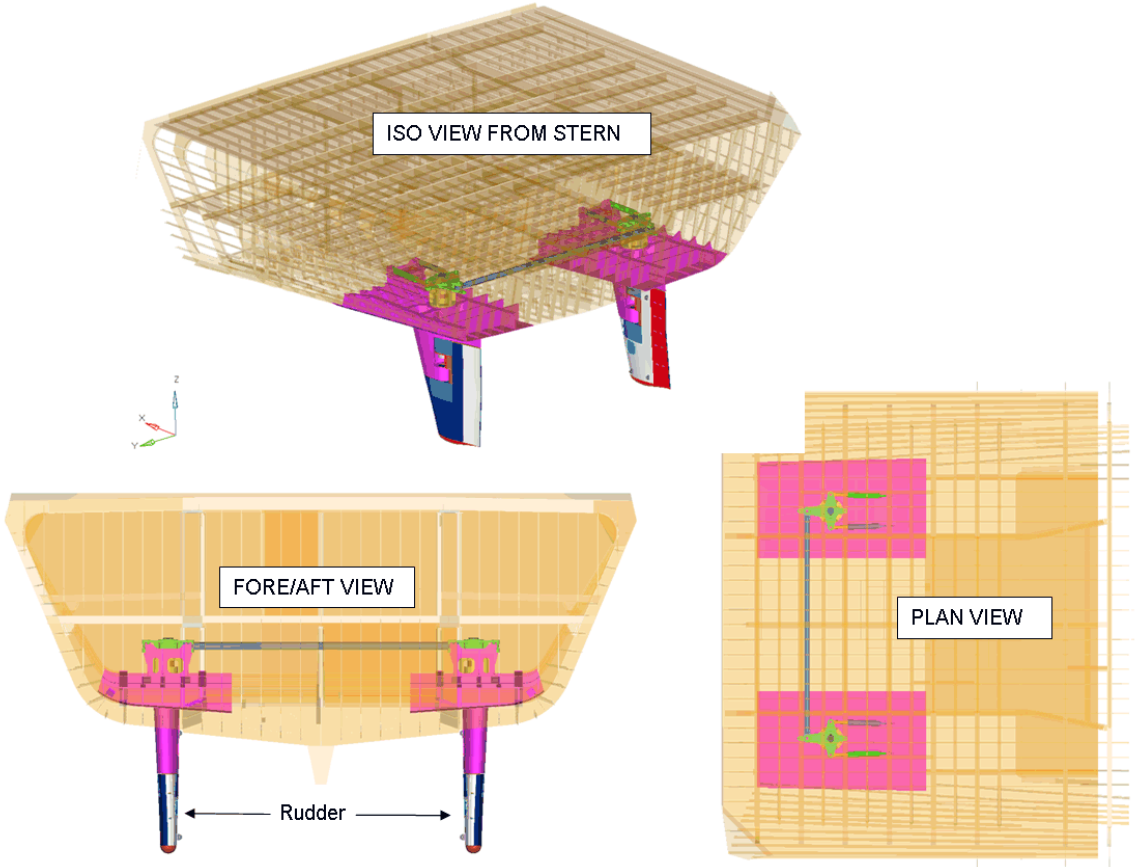
Dynamic analysis of ships steering gear

Introduction

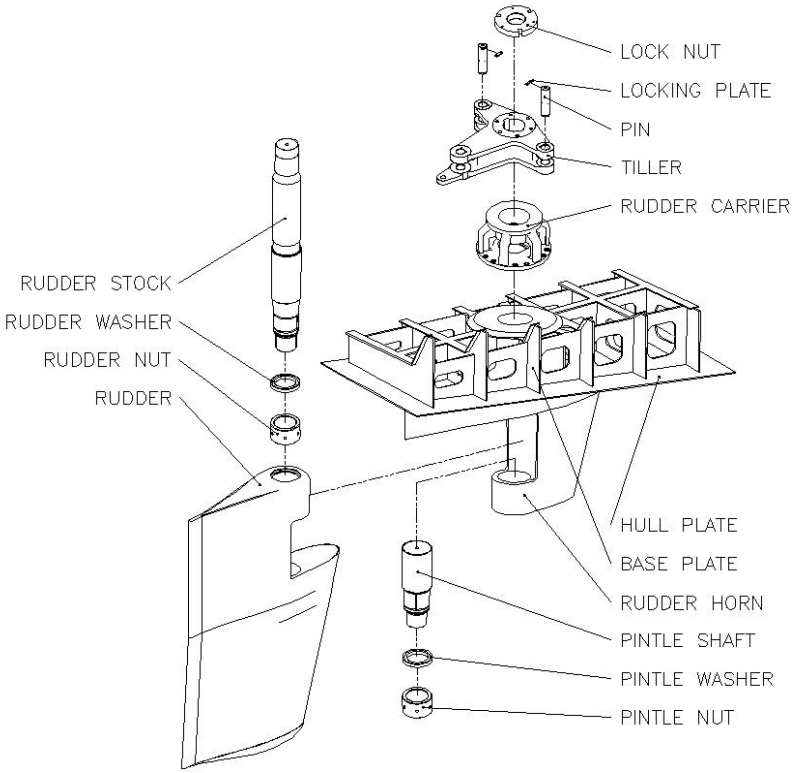
- Assystem UK Ltd (AUK) have undertaken a time domain dynamic analysis approach for the pressure pulse on externally mounted equipment and, in the same analysis, the shock event on internally mounted equipment.

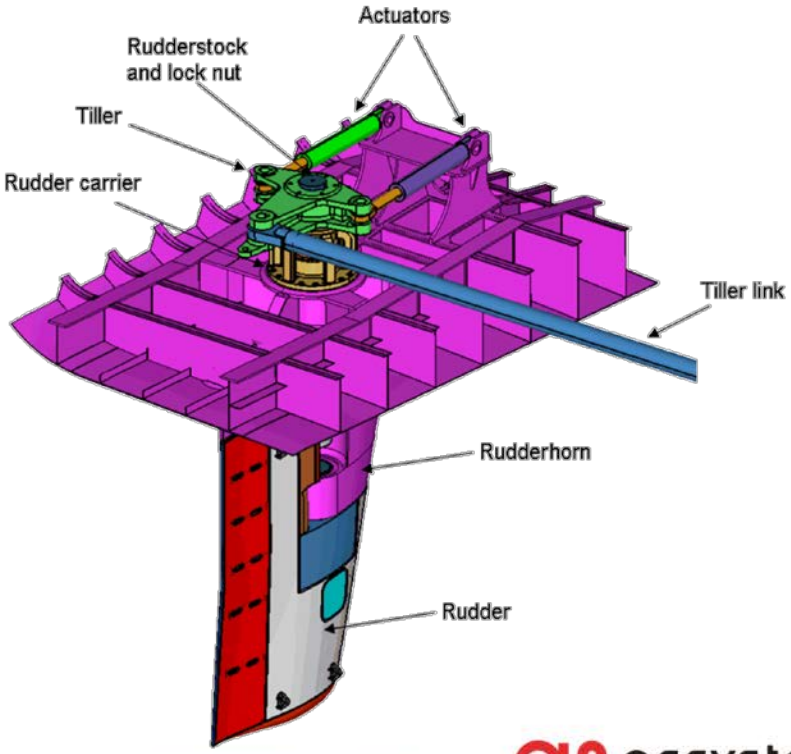


Dynamic analysis of ships steering gear

Description

- The rudders are semi spade (mariner) type. Each rudder is controlled by two double acting hydraulic rams which turn the tiller arm and are connected to the tiller load reaction sub assembly. A link bar is included that connects the port and starboard tiller arms and provides additional redundancy in the operation of the steering gear system.

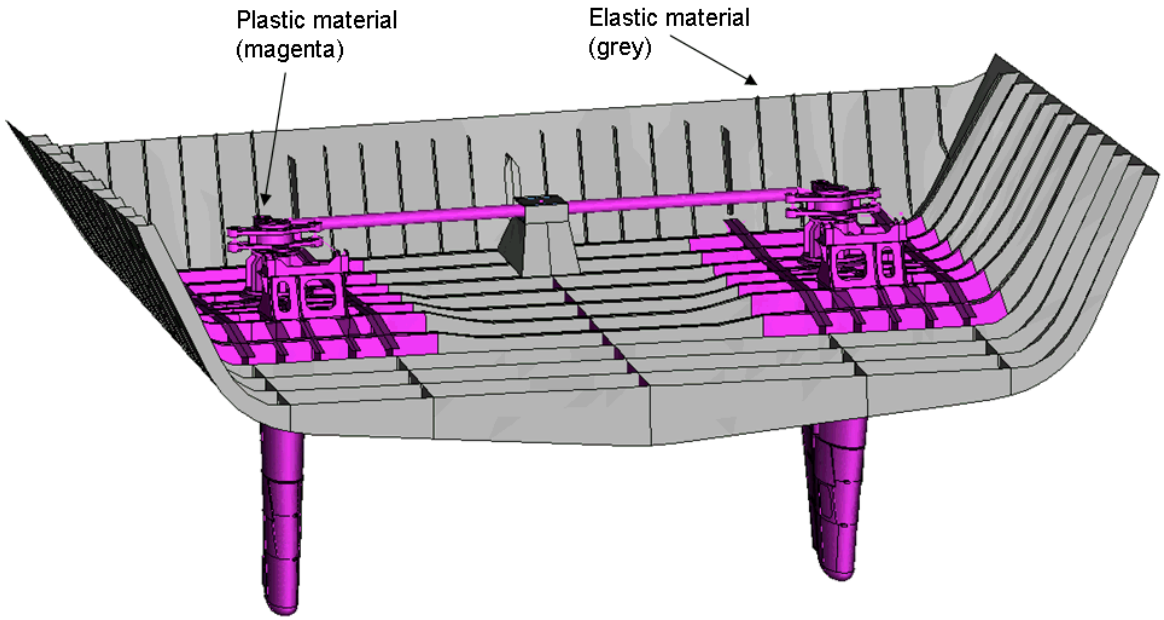




Dynamic analysis of ships steering gear

Finite Element Analysis

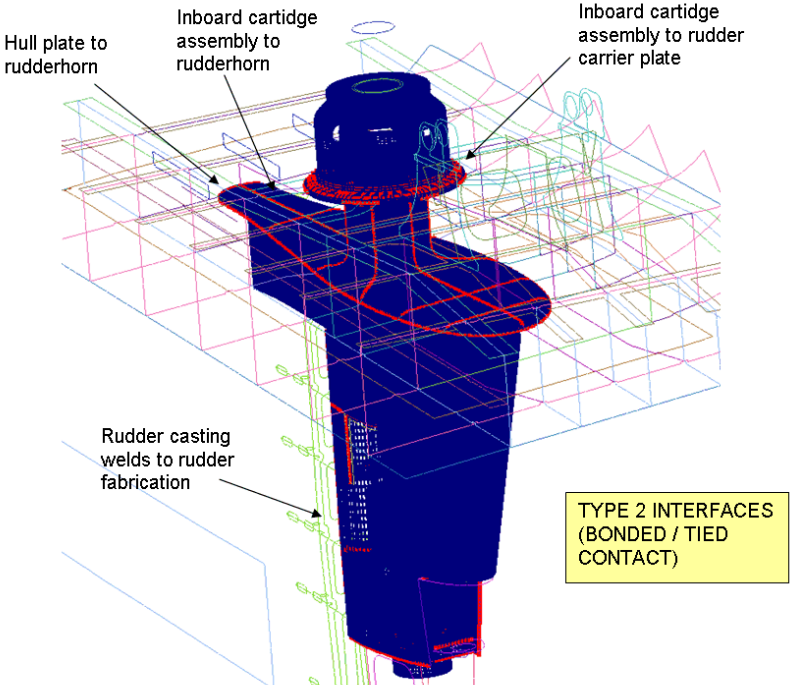
- The mesh was generated using Altair HyperMesh.
- HyperCrash was used to define the finite element model.
- The dynamic event was carried out using the explicit finite element code RADIOSS.
- The results were post-processed using HyperView.
- A combination of solid and shell elements were used.
- Rigid elements were included at the tiller pivot points.

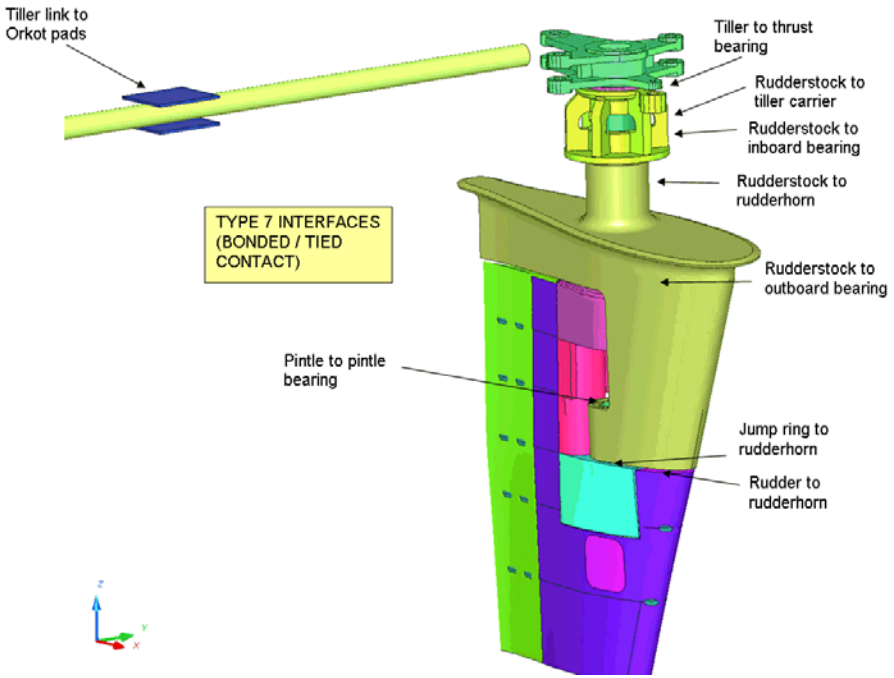


Dynamic analysis of ships steering gear

Interfaces

- Type 2 (bonded) interfaces
- Type 7 (frictional) interfaces

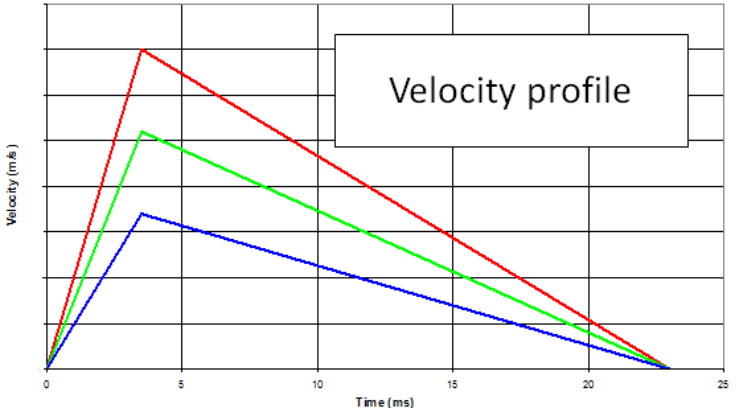


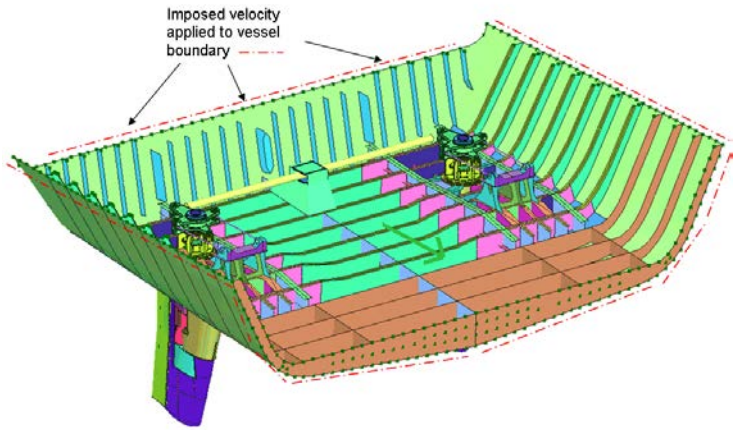


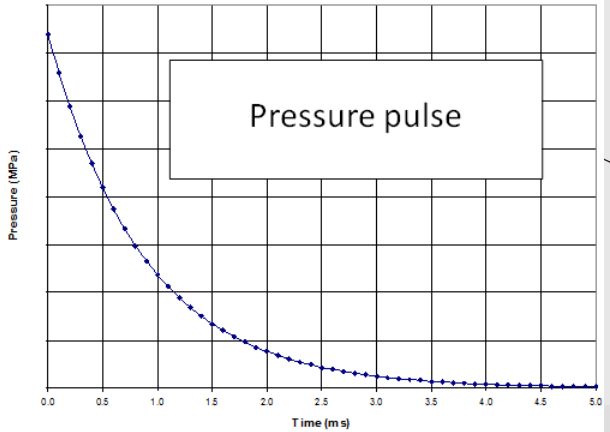
Dynamic analysis of ships steering gear

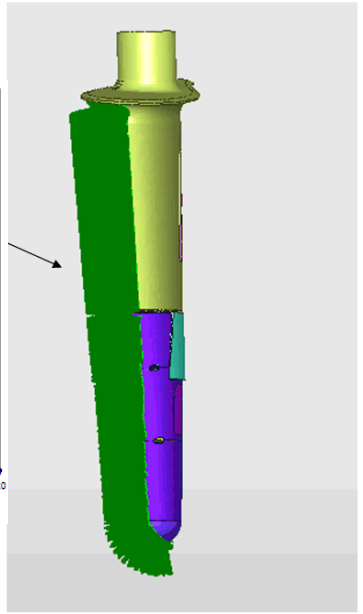
Loads

- A pressure pulse was applied to the external surfaces
- The velocity impulse was applied to the cut boundary
- The pressure pulse was delayed by 5.2 ms before being applied to the port rudder





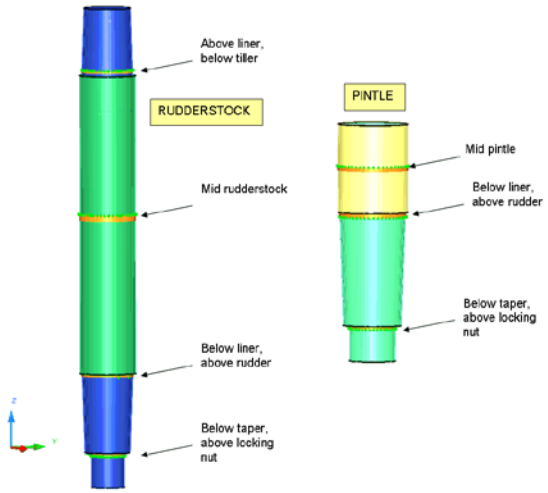


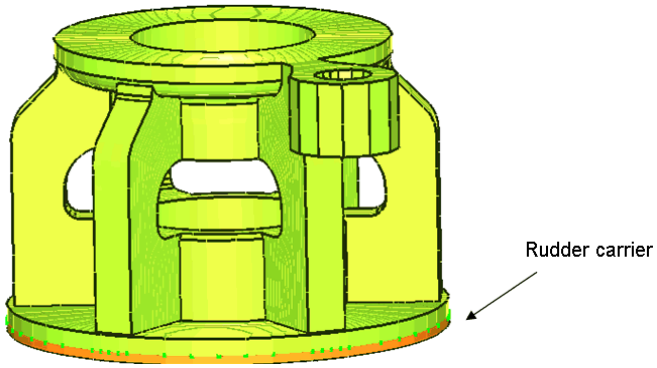


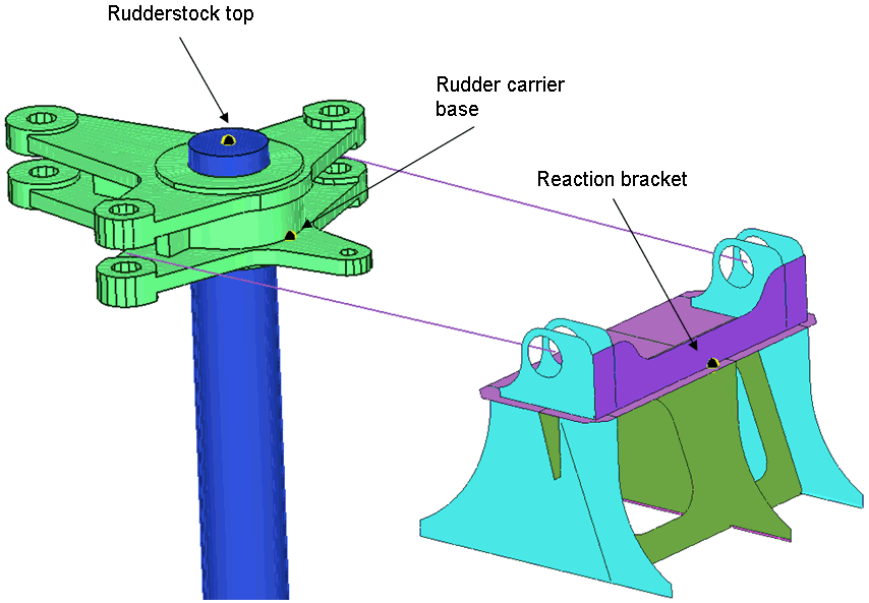
Dynamic analysis of ships steering gear

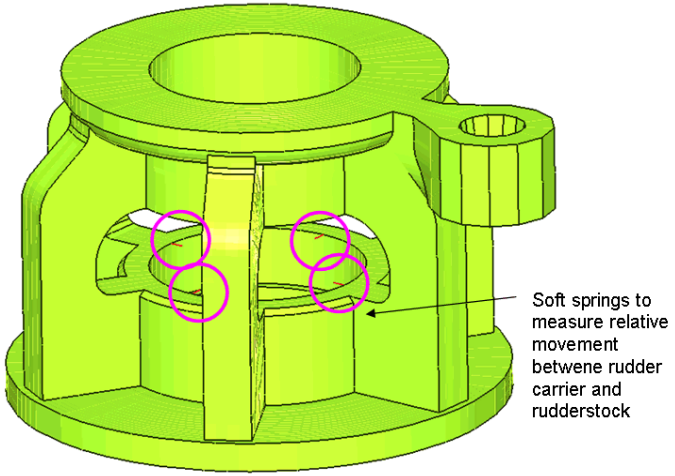
Output Metrics

- Plastic Strain
- Section Forces
- Seal Movement
- Actuator Forces
- Velocity Response









Dynamic analysis of ships steering gear

Solve

- The analyses were carried out for at least **70 ms**, ie approximately three times the time period of the loading (the applied velocity is zero after 23 ms).

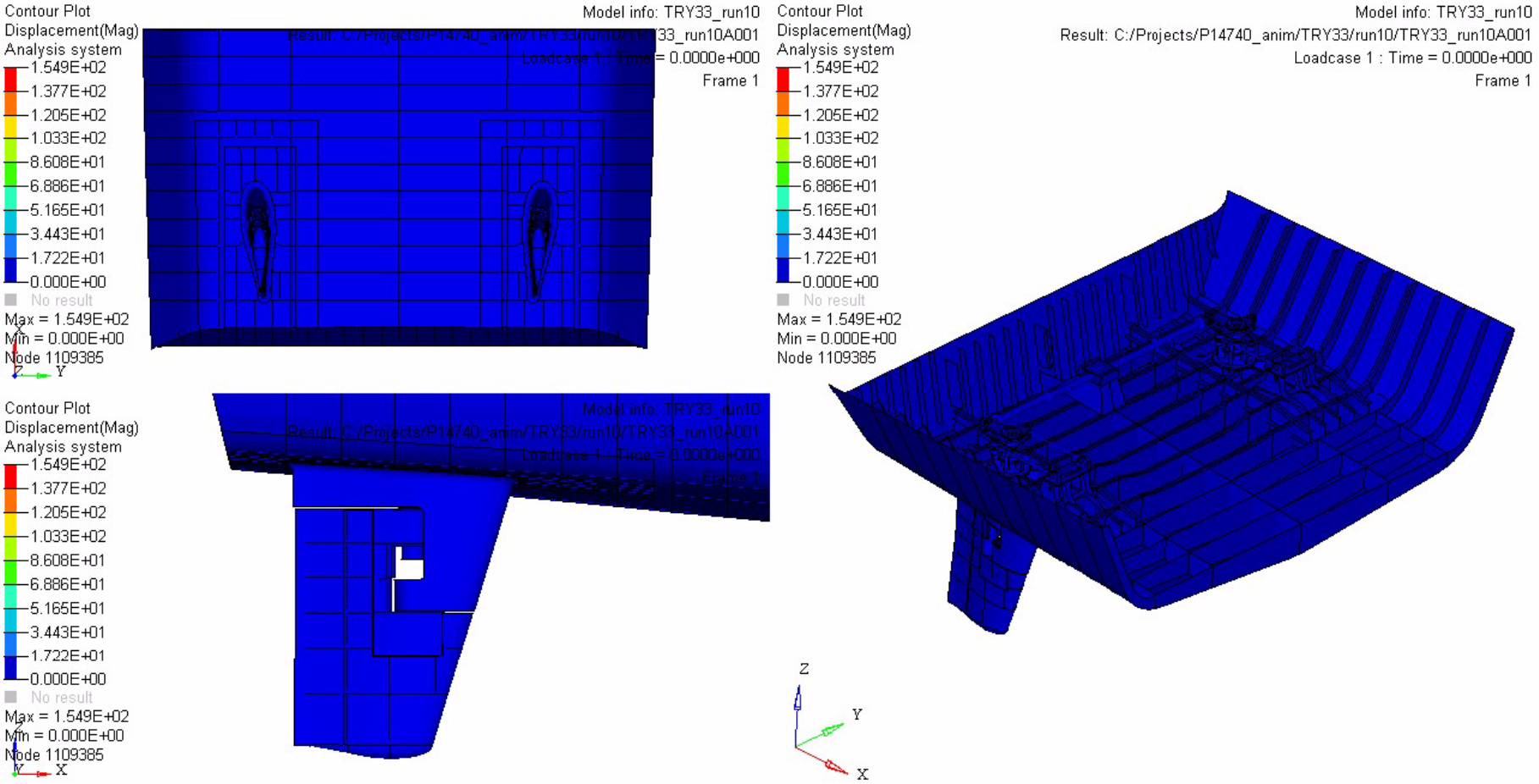
- A time increment of **1.5 µs** was chosen, nodal mass was increased to ensure that this time increment could be maintained and the model remained numerically stable.

- Animation files were written every **0.5 ms**, with time history data written every 25 µs. The analyses were carried out on a compute cluster with between 48 and 64 parallel cores. The double precision solver was used and the parallel processing option with RADIOSS was enabled to ensure that the number and location for the domains chosen for parallel solving would not affect the solution.

Dynamic analysis of ships steering gear

Results

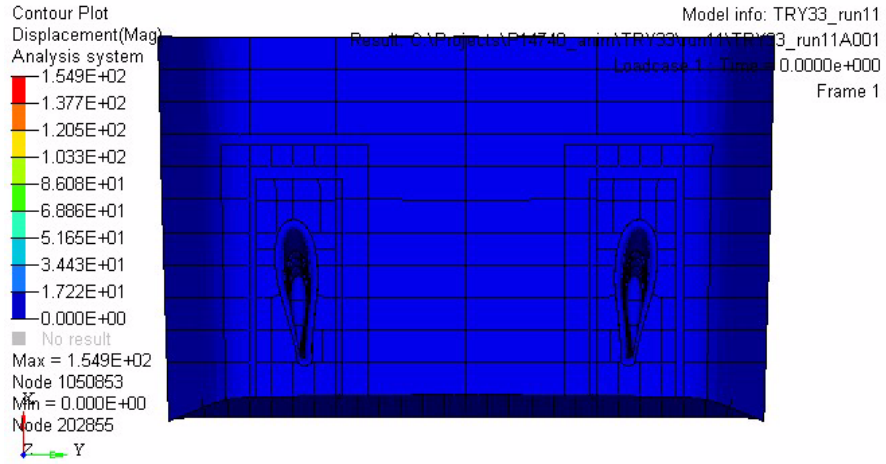
- Fore-aft results

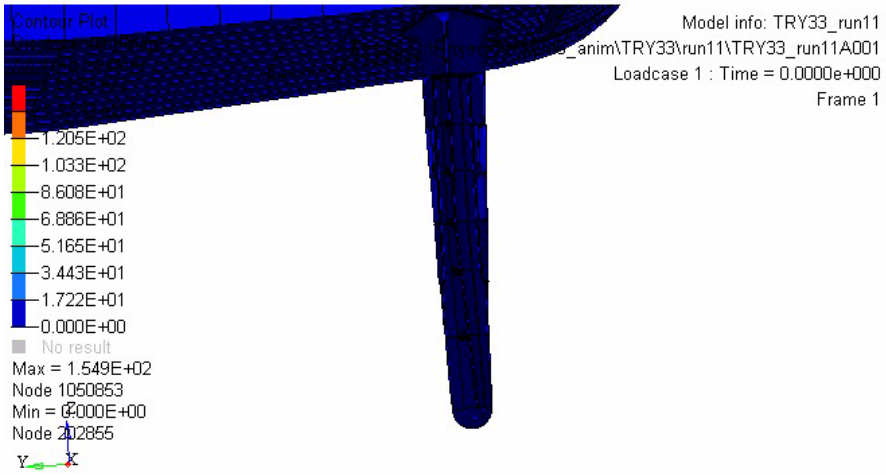


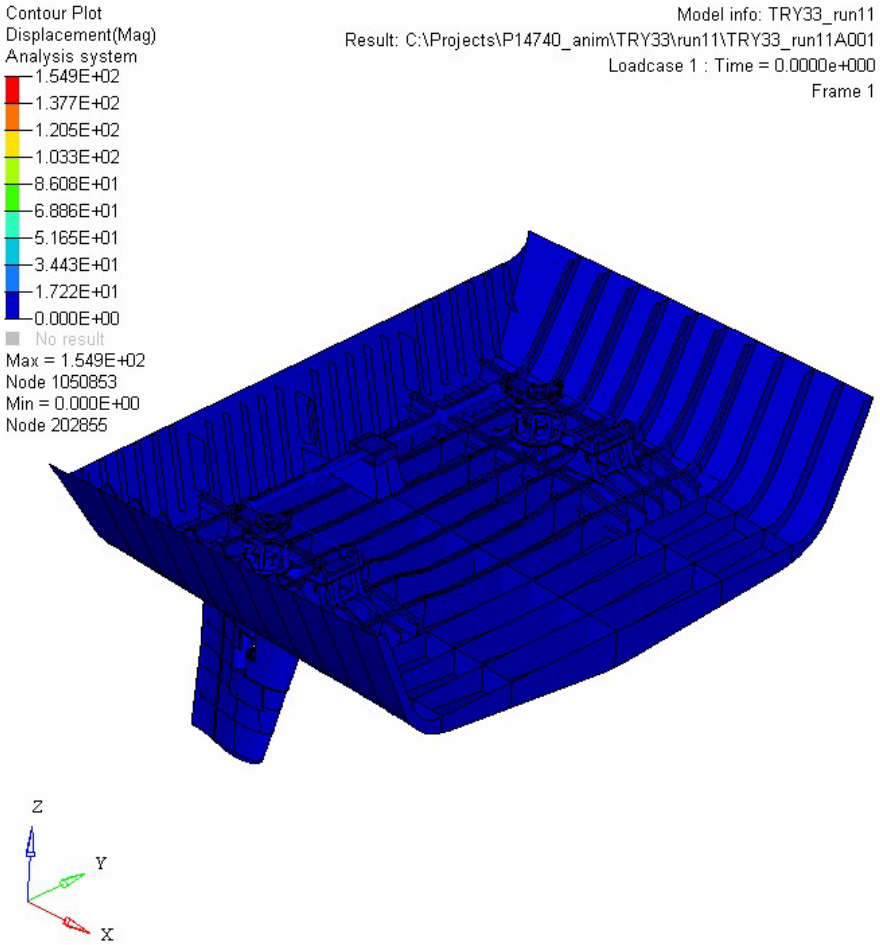
Dynamic analysis of ships steering gear

Results

- Athwartship results



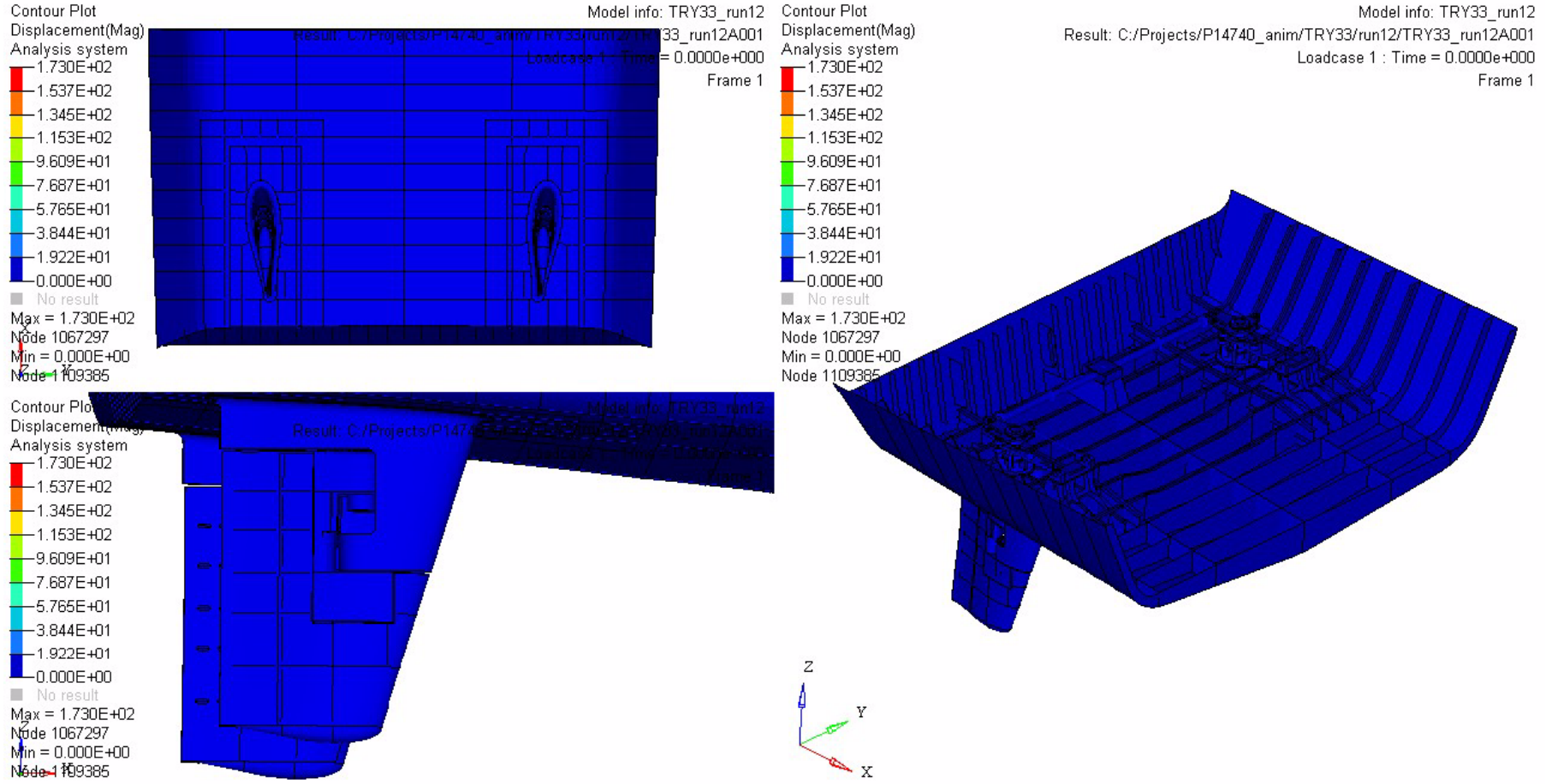




Dynamic analysis of ships steering gear

Results

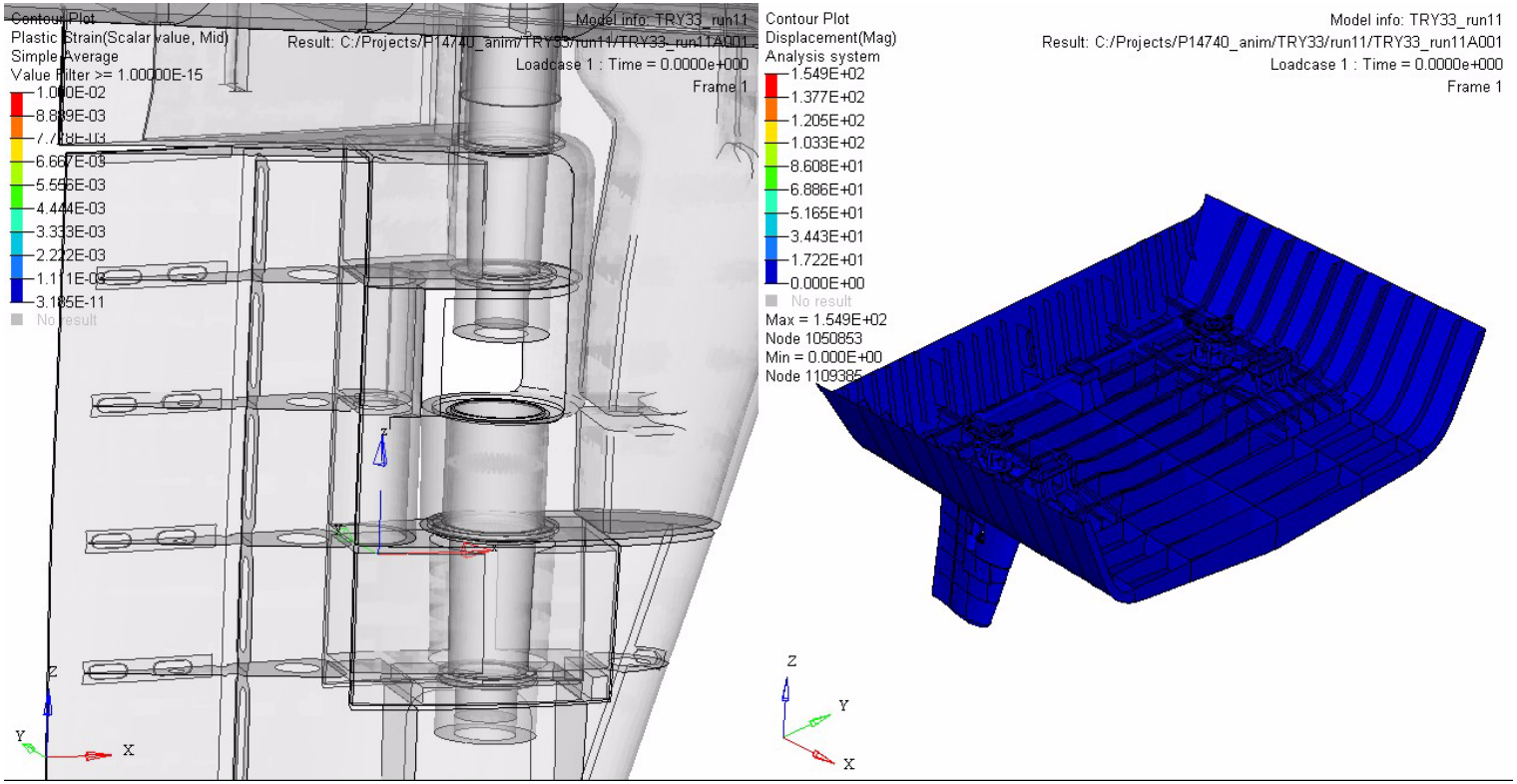
- Vertical results



Dynamic analysis of ships steering gear

Assessment

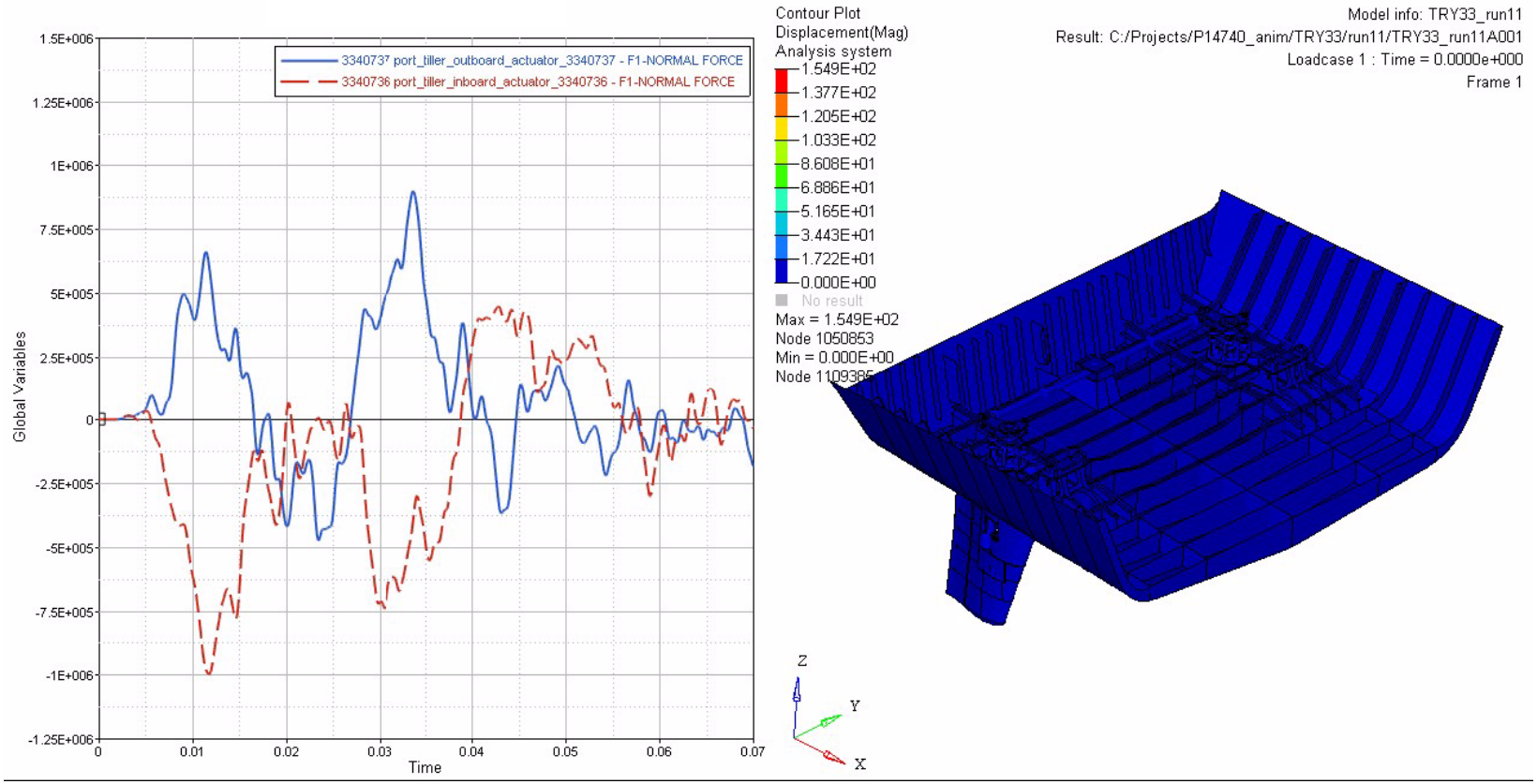
- Plasticity
- The acceptance criteria zero plastic strain, small plastic deformations of a component are permissible providing these do not impair the function of the equipment



Dynamic analysis of ships steering gear

Assessment

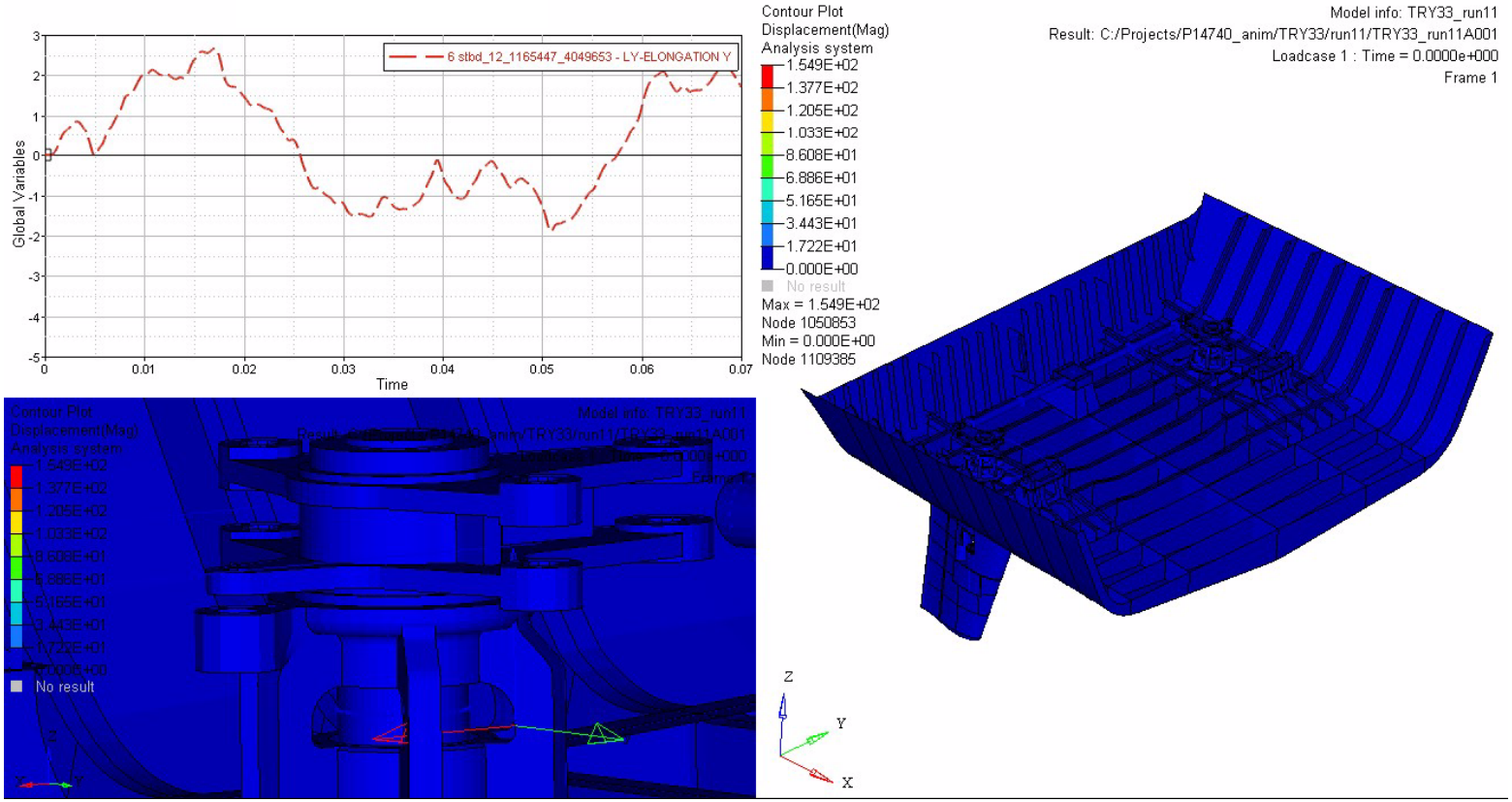
- Extract forces at actuators and top taper
- Compare against rating



Dynamic analysis of ships steering gear

Assessment

- Extract relative displacements at seal
- Check seal integrity



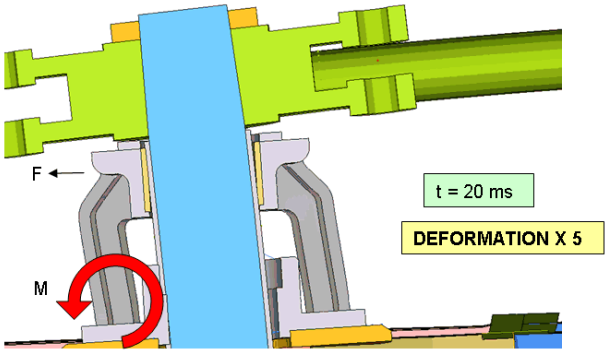
Dynamic analysis of ships steering gear

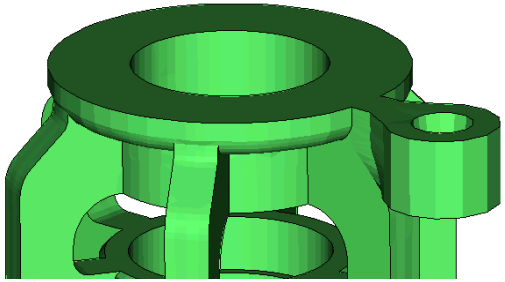
Design Improvements

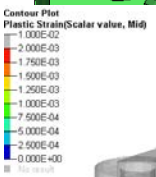
- The initial design of the rudder carrier showed excessive plasticity in the lower legs produced by a bending moment resulting from impact between the rudderstock and carrier. Topology optimisation was employed to improve the design.

Rudderstock impacts inner Orkot bearing at top of carrier with force 'F'.

This produces an overturning moment 'M' at the base of the rudder carrier, this is reacted by the bolt group and the legs of the carrier.

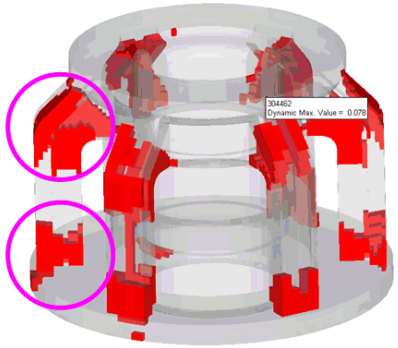


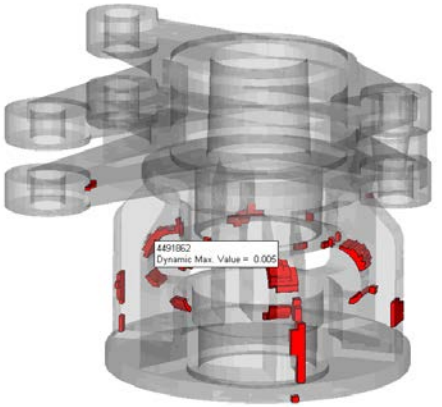




Red shows regions of carrier with equivalent plastic strain greater than 0.2%.

There is through-wall yielding at the base and shoulder of the rudder carrier.





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Conclusions

- The rudder welded and case components within the client scope of supply meet the requirements for longitudinal, athwartships and vertical shock. Some localised plasticity is predicted, but this will not affect the continued operation.

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